(12) UK Patent Application (19) GB (11) 2 314 167 (13) A

(43) Date of A Publication 17.12.1997

(21) Application No 9612347.6

(22) Date of Filing 13.06.1996

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(51) INT CL[6]
G02F 1/1335 , G02B 5/30 7/12 , H04N 13/00 15/00

(52) UK CL (Edition O)
G2F FSX F23E F25F F25P1
G2J JS3B JX15
H4F FDD FD1B9 FD15 FD27C1 FD27P FD27T1

(56) Documents Cited
GB 2296151 A   EP 0477882 A   US 5264964 A

(58) Field of Search
UK CL (Edition O) G2F FSX , H4F FDD
INT CL[6] G02F 1/1335 , H04N 13/00
ONLINE: EDOC WPI

(54) **Liquid crystal display and polarized spectacles**

(57) A liquid crystal display for stereoscopic viewing comprises a patterned reflective and cholesteric polarizer 26 having two sets of regions which transmit oppositely handed circularly polarised light. The device also includes a quarter wave film 24 and is illuminated by a pair of oppositely polarized light sources. The display is viewed by spectacles having eyepieces of cholesteric material , the eyepieces being arranged to transmit oppositely handed circular polarizations.

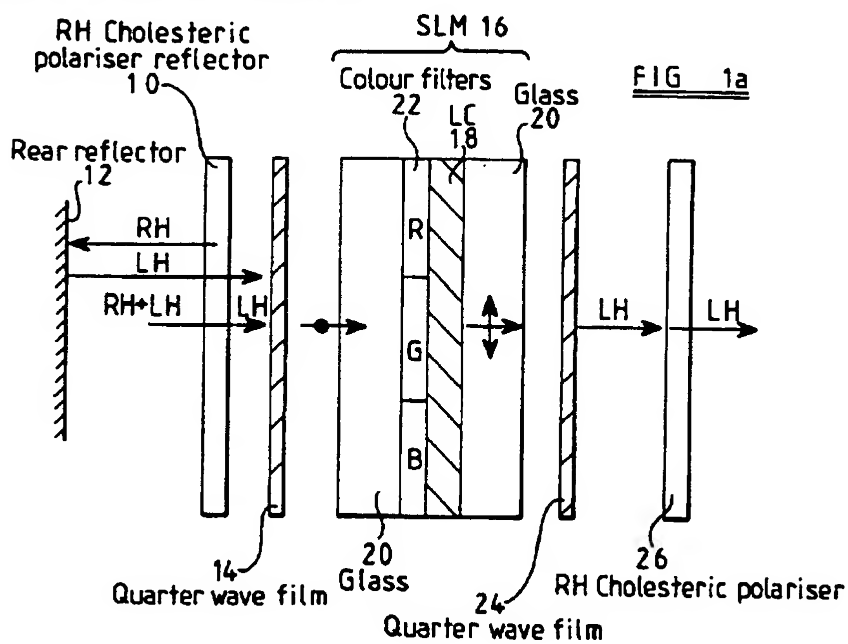


FIG 1a

GB 2 314 167 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

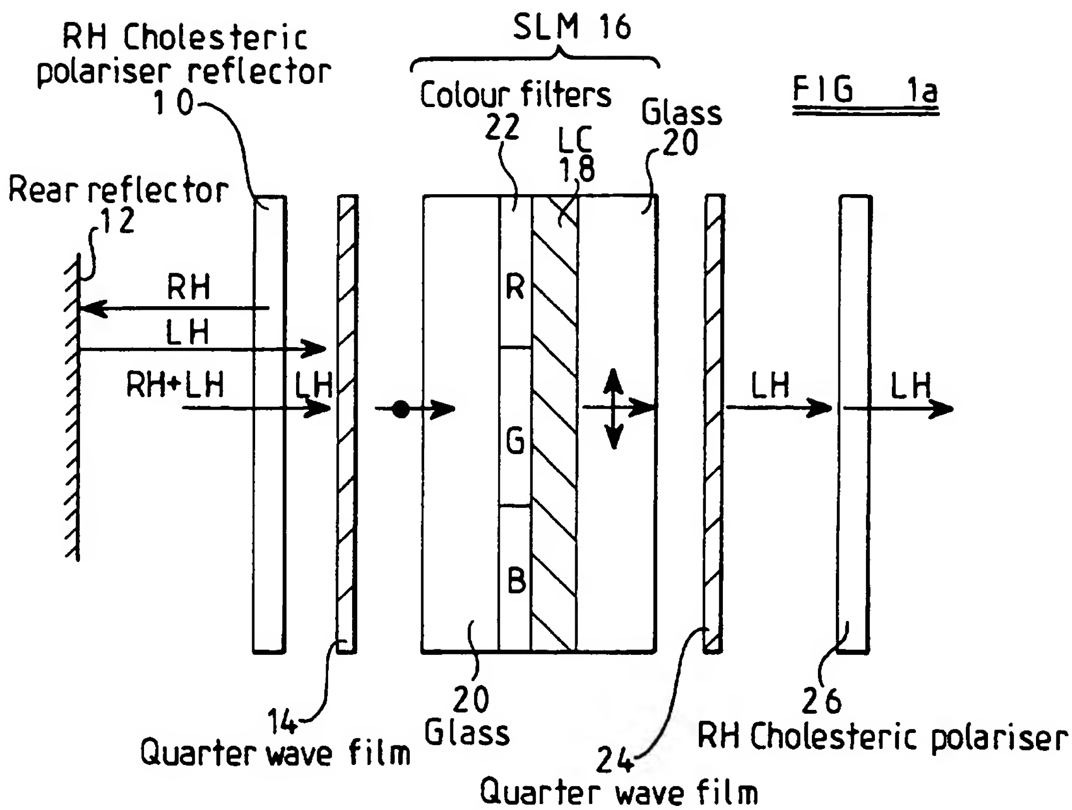

SLM 16
RH Cholesteric
polariser reflector
10
Colour filters
22
LC
18
Glass
20
Rear reflector
12
RH
LH
RH+LH
LH
R
G
B
LH
LH
14
Quarter wave film
20
Glass
24
Quarter wave film
26
RH Cholesteric polariser

FIG 1a

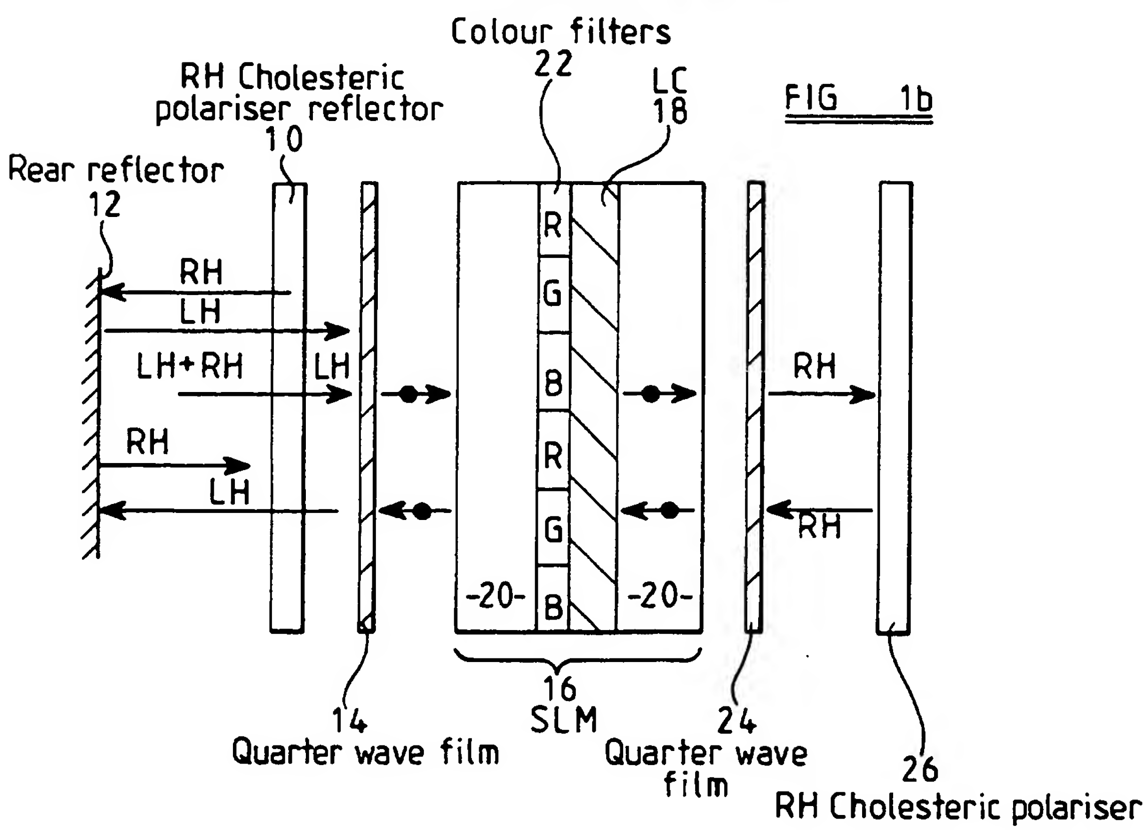

Colour filters
22
LC
18
RH Cholesteric
polariser reflector
10
Rear reflector
12
RH
LH
LH+RH
LH
RH
LH
R
G
B
R
G
B
-20-
-20-
RH
RH
16
SLM
14
Quarter wave film
24
Quarter wave
film
26
RH Cholesteric polariser

FIG 1b

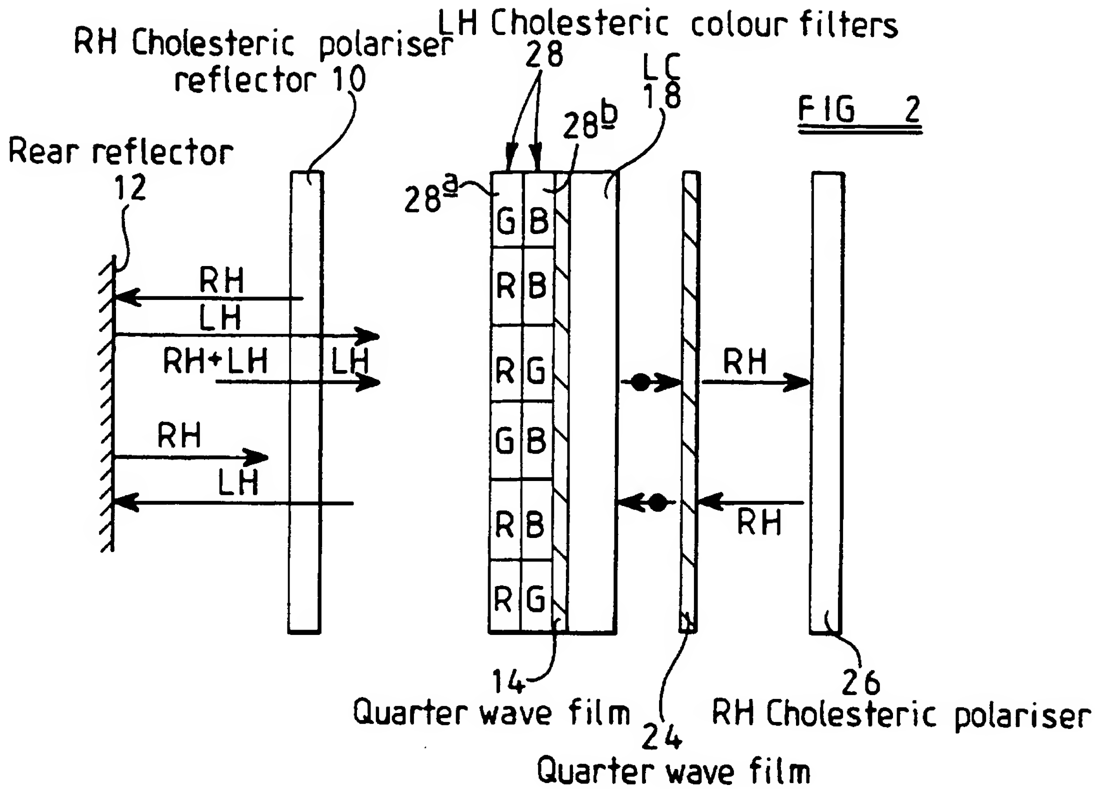

RH Cholesteric polariser reflector 10
LH Cholesteric colour filters 28
28a
28b
LC 18
Rear reflector 12
RH
LH
RH+LH
LH
RH
LH
G B
R B
R G
G B
R B
R G
RH
RH
14
Quarter wave film
24
Quarter wave film
26
RH Cholesteric polariser

FIG 2

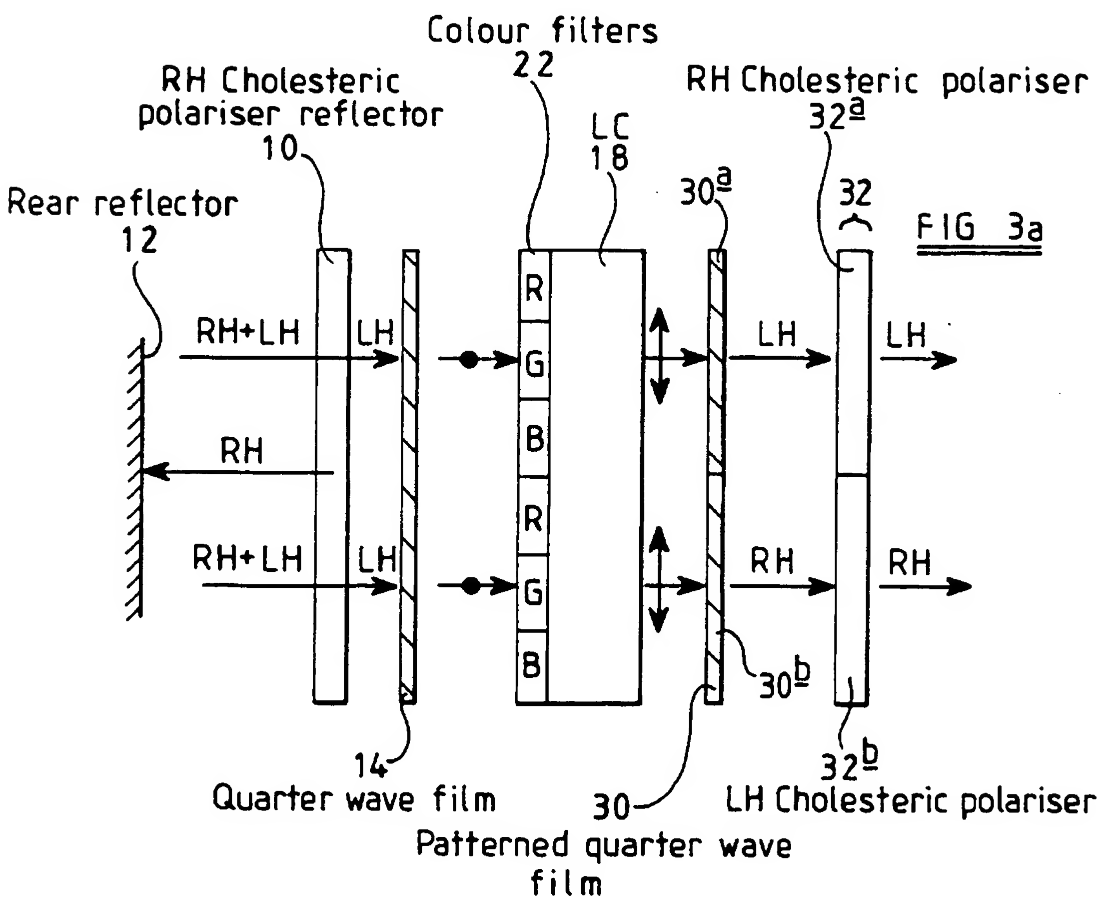

Colour filters 22
RH Cholesteric polariser reflector 10
LC 18
RH Cholesteric polariser 32a
30a
32
Rear reflector 12
RH+LH
LH
RH
RH+LH
LH
R
G
B
R
G
B
LH
LH
RH
RH
30b
14
Quarter wave film
30
Patterned quarter wave film
32b
LH Cholesteric polariser

FIG 3a

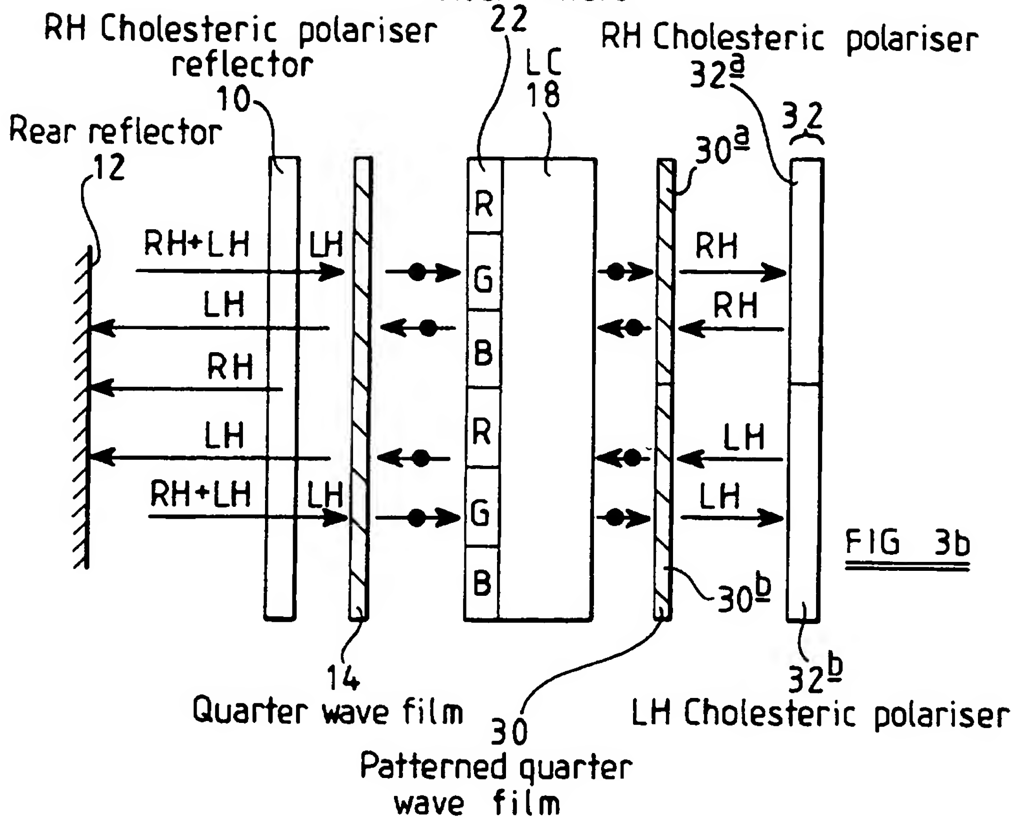


FIG 3b

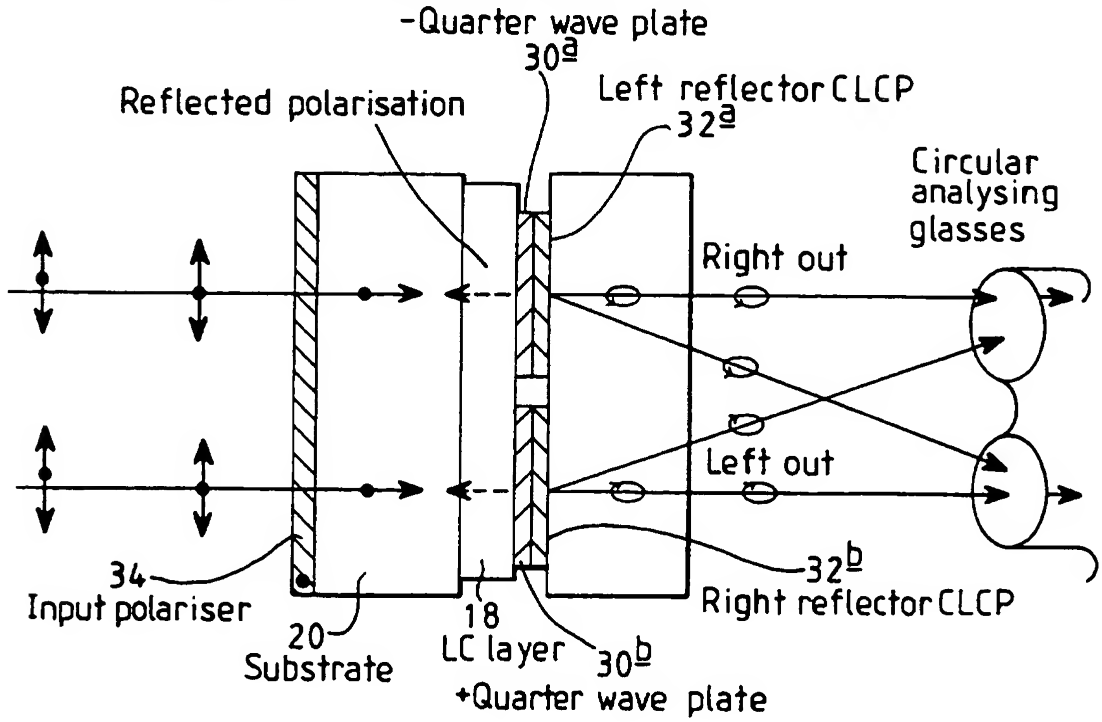


FIG 4A Device for stereoscopic or autostereoscopic display incorporating reflective polarisers.

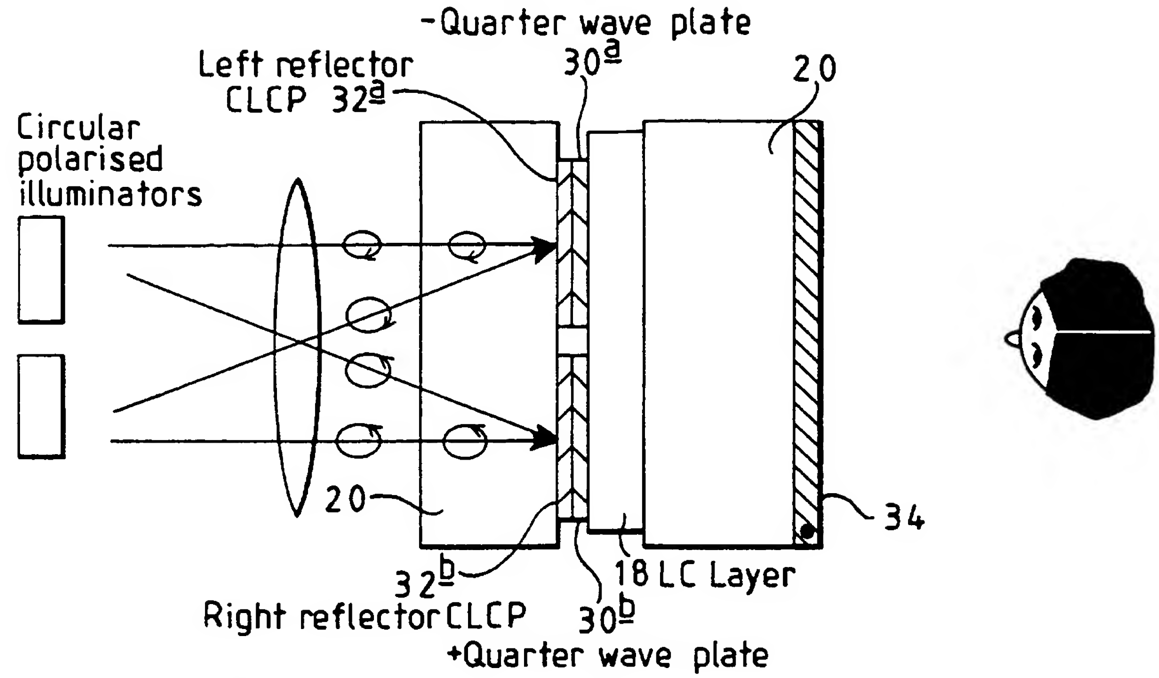
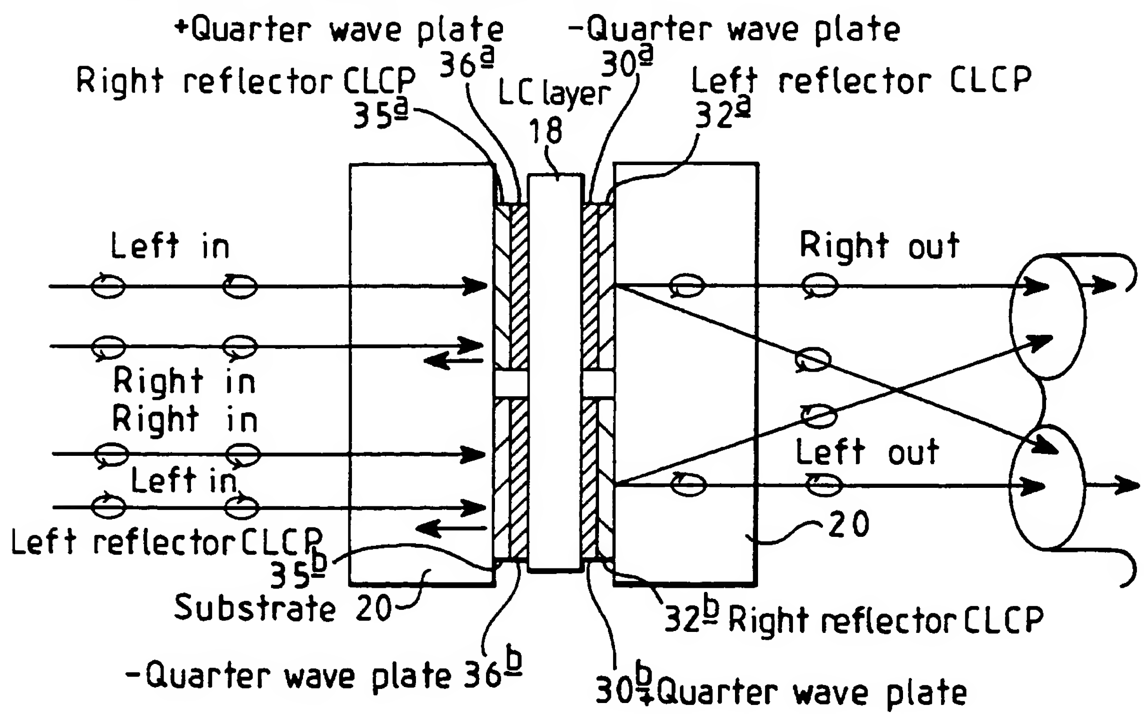


FIG 4B Effect of front reflection in autostereoscopic display with pixellated cholesteric input polarisers.

FIG 5 Device for autostereoscopic and stereoscopic display incorporating reflective polarisers.



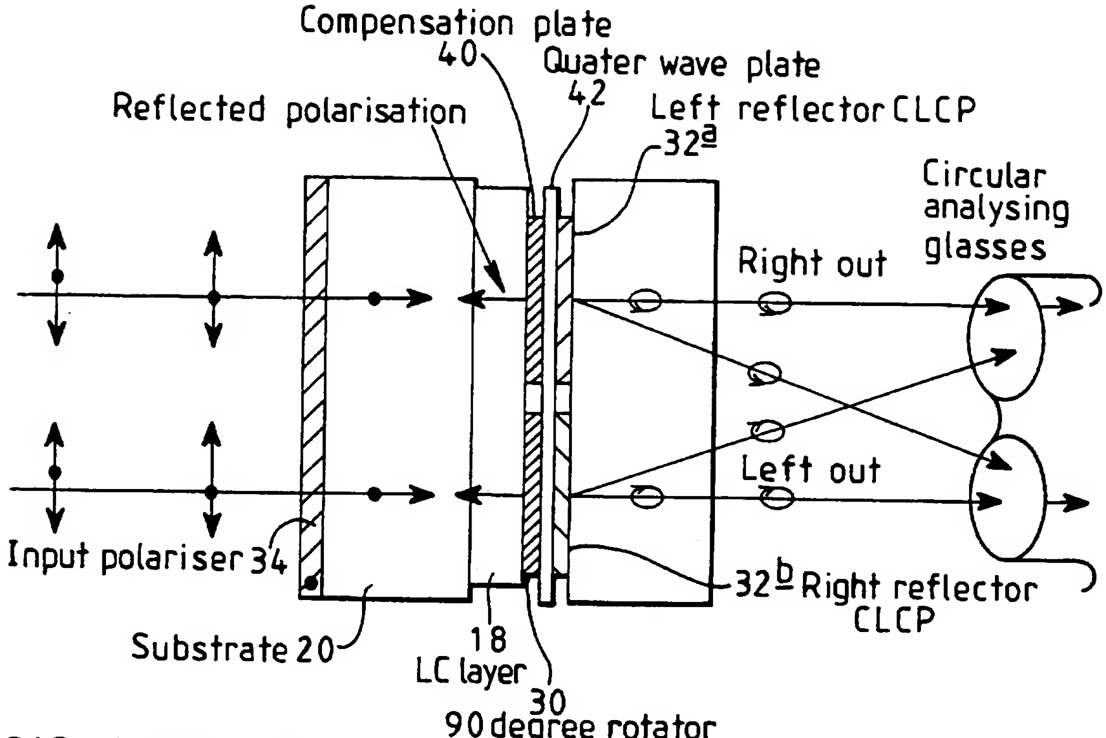


FIG 6 Device for stereoscopic or autostereoscopic display incorporating reflective polarisers and 90 degree rotators.

FIG 7 Device for autostereoscopic and stereoscopic display incorporating reflective polarisers and 90 degree rotators.

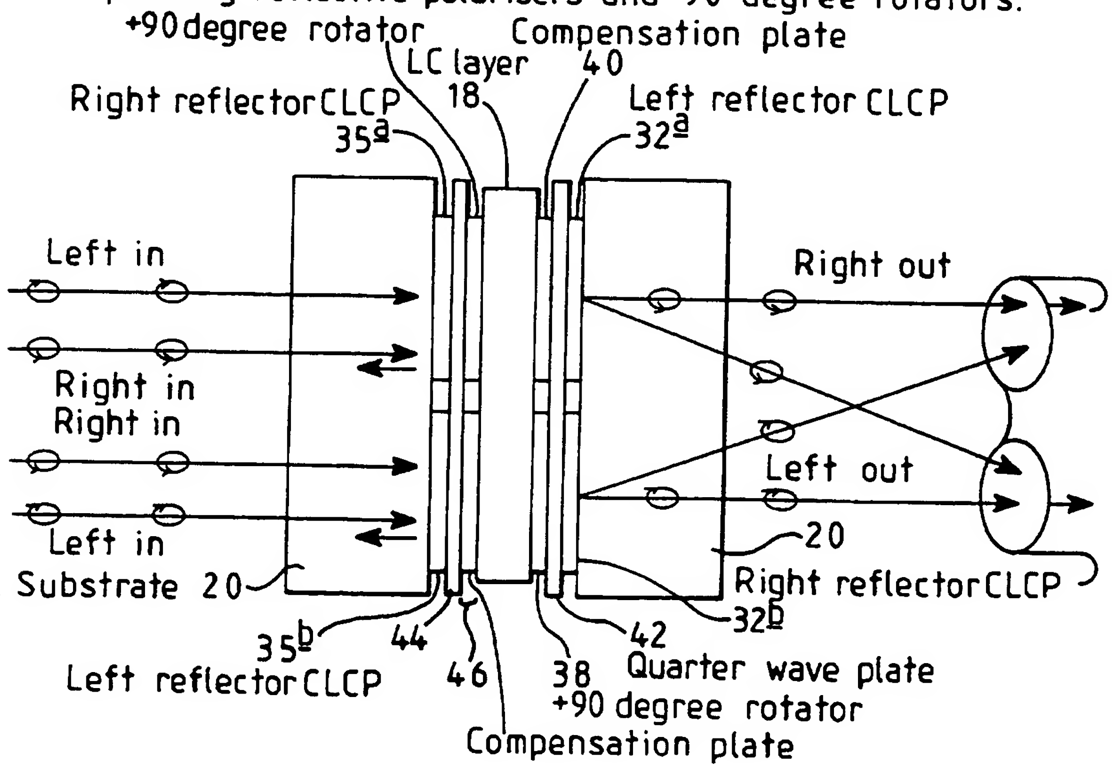


FIG 8 Device for autostereoscopic and stereoscopic display incorporating input reflective polarisers and output absorbing polarisers to avoid frontal reflection problems.

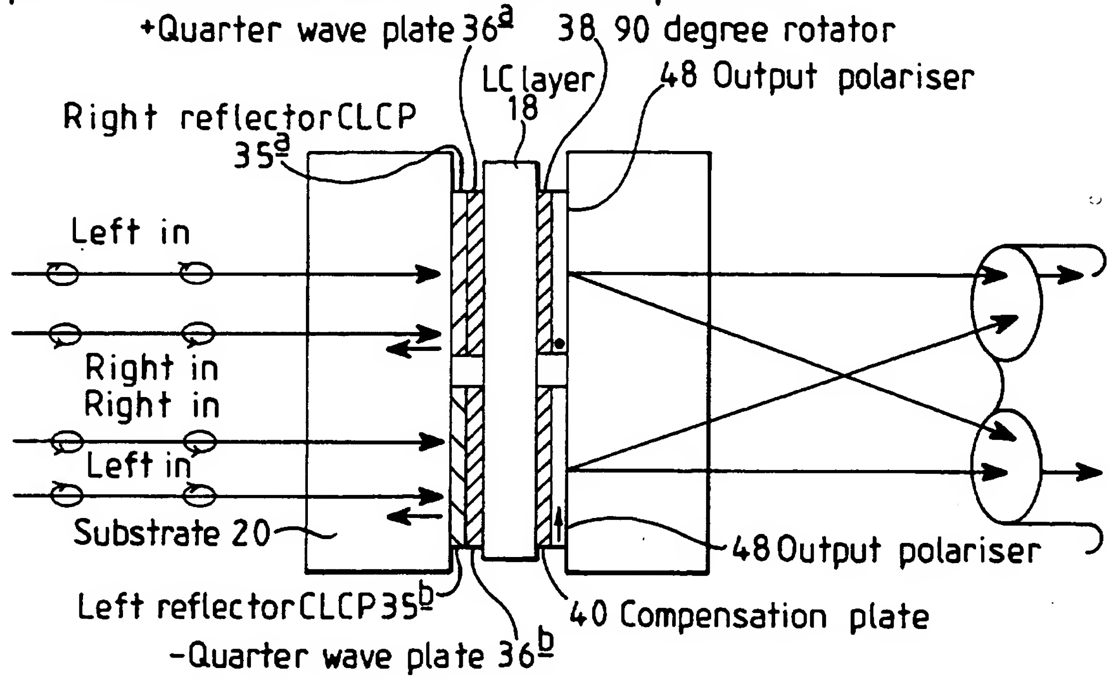
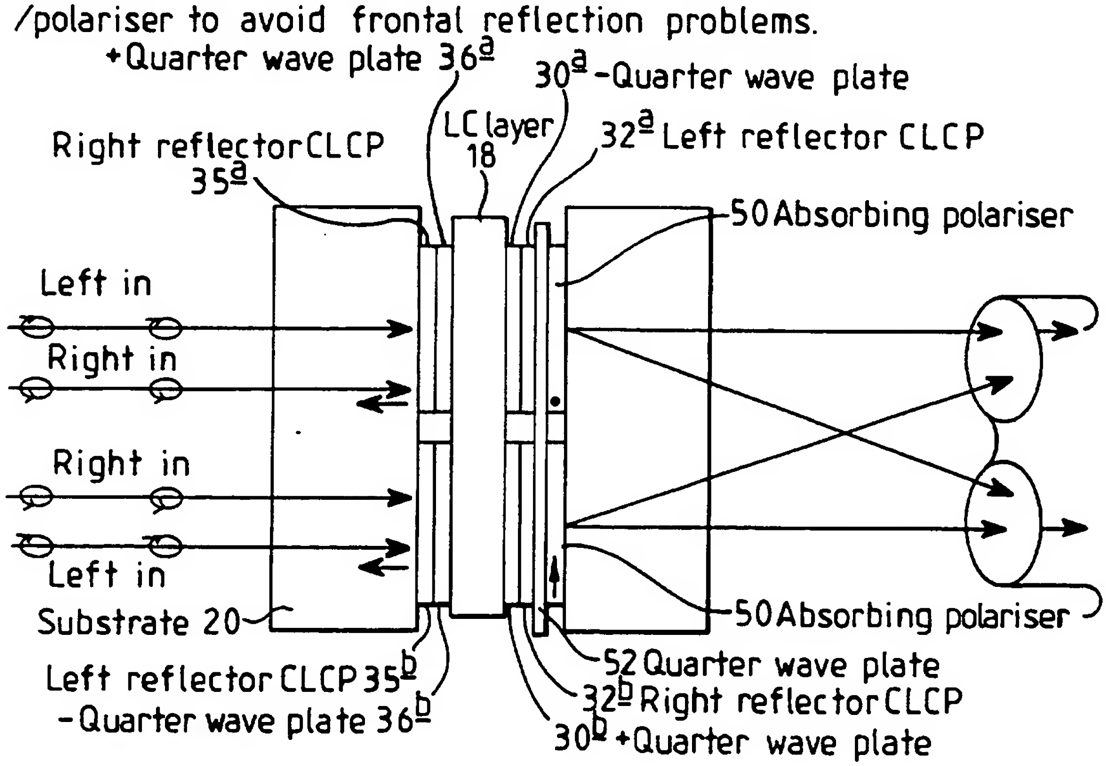


FIG 9 Device for autostereoscopic and stereoscopic display incorporating reflective polarisers and output quarter wave plate /polariser to avoid frontal reflection problems.



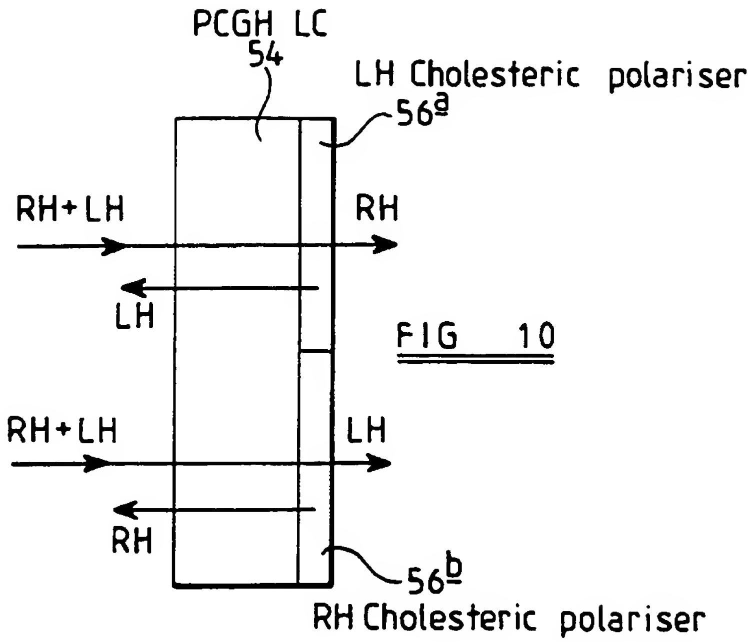

PCGH LC
54
LH Cholesteric polariser
56a
RH+LH
RH
LH
RH+LH
LH
RH
56b
RH Cholesteric polariser

FIG 10

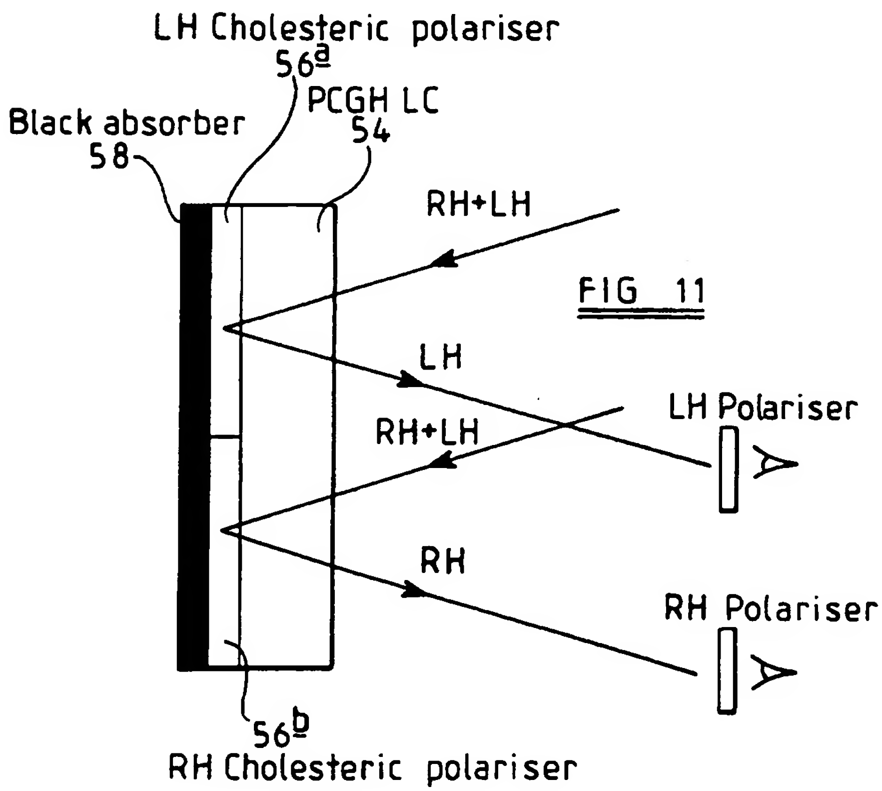

LH Cholesteric polariser
56a
PCGH LC
54
Black absorber
58
RH+LH
LH
LH Polariser
RH+LH
RH
RH Polariser
56b
RH Cholesteric polariser

FIG 11

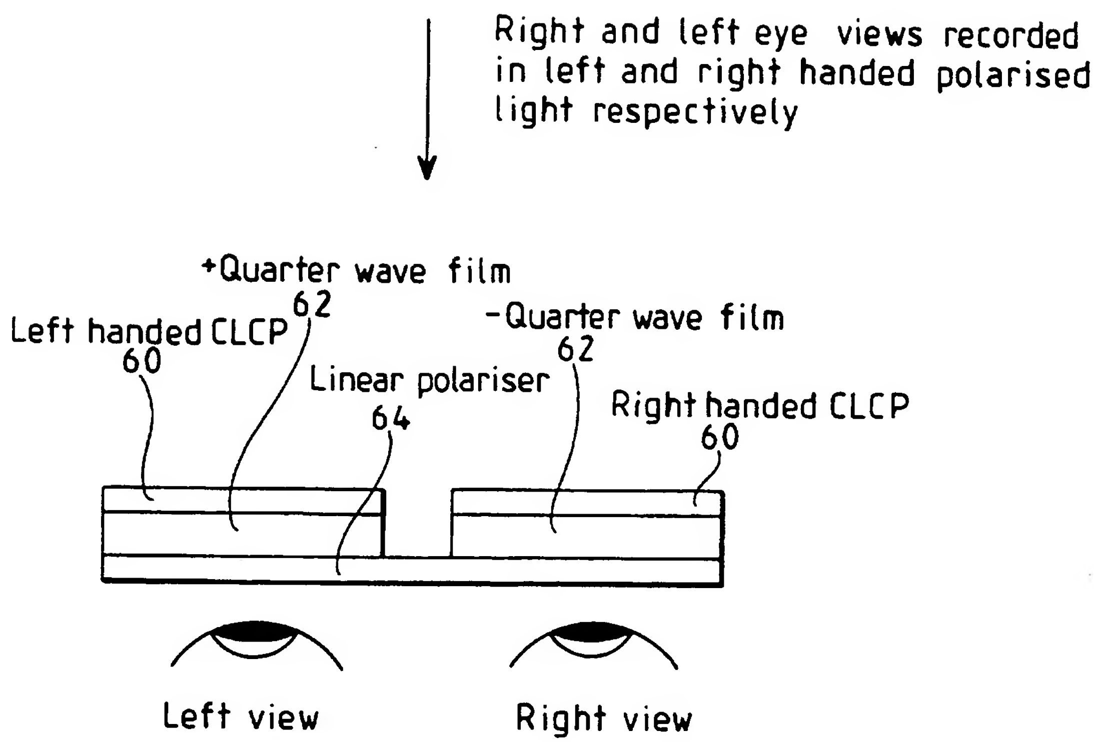


FIG 12 The use of cholesteric materials in analysing spectacles

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LIQUID CRYSTAL DEVICE, DISPLAY ARRANGEMENT INCORPORATING SAME, AND POLARIZED VIEWING SPECTACLES

This invention relates to a liquid crystal device suitable for use in a display, for example a 3D stereoscopic or autostereoscopic display.

Liquid crystal devices used in displays generally comprise a liquid crystal layer positioned between a pair of polarizers. Light incident upon a first one of the polarizers, hereinafter referred to as the input polarizer, is split into two orthogonal polarization components, one of the components being transmitted by the input polarizer, the other component being absorbed thereby. The transmitted component is incident upon and transmitted by the liquid crystal layer which is controlled so that in one state thereof, the liquid crystal material has no effect upon the polarization of light transmitted by the layer, while in a second operating state, the liquid crystal material orthogonally converts the polarization of light incident thereon.

The light transmitted by the liquid crystal material is incident upon the second, output polarizer which is, for instance, oriented with its optic axis perpendicular to that of the input polarizer. When the liquid crystal layer is in its first state, substantially no light is transmitted by the liquid crystal device, substantially all of the light transmitted by the input polarizer being absorbed by the output polarizer. Thus the device appears dark. When the liquid crystal layer is in its second state, the light transmitted by the liquid crystal layer is of the correct polarization to be transmitted by the output polarizer. Thus the liquid crystal device

appears bright. If the liquid crystal layer is in an intermediate state, the device appears grey, a range of grey levels being possible.

Such a device is inefficient as the polarizers absorb a large proportion of light incident thereon. The input polarizer, when used with an unpolarized light source, absorbs more than 50% of light incident thereon, and when the liquid crystal device appears dark substantially all light emitted by the light source is absorbed by the polarizers.

EP 0606940, EP 0634674, US 5325218 and US 5295009 each describe arrangements whereby the input polarizer is replaced by a cholesteric material which transmits a first handedness of circular polarization and reflects a second handedness. The reflected light is reflected by a mirror or other suitable reflector and is thus converted to the first handedness. After reflection by the mirror, this component is incident upon and is transmitted by the cholesteric material. Where such a polarizer is used with a liquid crystal material requiring linearly polarized light, a quarter wave plate is used to convert the transmitted circularly polarized light to plane polarized light.

The use of a cholesteric material as the input polarizer improves the efficiency of the liquid crystal device in that substantially all of the light emitted by an unpolarized light source is incident upon the liquid crystal layer rather than 50% or less where an absorbing polarizer is used.

US 5295009 and US 5325218 further describe the use of cholesteric materials as output polarizers.

According to a first aspect of the present invention, there is provided a liquid crystal device as defined in appended Claim 1.

According to a second aspect of the invention, there is provided a display arrangement as defined in appended Claim 15.

According to a third aspect of the invention, there is provided polarized viewing spectacles as defined in appended Claim 17.

Preferred embodiments of the invention are defined in the other appended claims.

It is thus possible to provide a liquid crystal device which may be used in a stereoscopic or autostereoscopic display providing increased efficiency of use of light. In particular, the patterned reflective polariser returns light, which would conventionally have been absorbed, for re-use. It is thus possible to provide a brighter display or to reduce the required lighting power. Further, when a patterned cholesteric polariser is used, this may be disposed between substrates of the liquid crystal device because it is capable of withstanding temperatures during manufacture of such a device. Thus, cross talk between pixels can be substantially reduced by the proximity of the polariser and the liquid crystal layer.

The invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figures 1a and 1b illustrate a liquid crystal device incorporating a reflecting polarizer;

Figure 2 illustrates another liquid crystal device incorporating a reflecting polarizer;

Figures 3a and 3b illustrate a liquid crystal device in accordance with a first embodiment of the invention;

Figures 4a and 4b illustrate a liquid crystal device in accordance with a second embodiment;

Figures 5 to 11 illustrate liquid crystal devices in accordance with further embodiments of the invention; and

Figure 12 illustrates the use of cholesteric materials in analysing spectacles.

The liquid crystal devices shown in Figures 1a, 1b and 2, although not constituting embodiments of the invention, are illustrated and described so as to assist understanding of the embodiments of the present invention.

The liquid crystal device shown in Figures 1a and 1b comprises a white light source (not shown) arranged to emit unpolarized light. The light source is located between or arranged to emit light to the space between a reflective circular polarizer in the form of a right hand (RH) cholesteric polariser 10 and a reflector 12. Some of the light emitted by the light source is incident directly upon the cholesteric polariser 10, the reflector 12 being shaped and positioned such that substantially all of the light not incident directly upon the cholesteric polarizer 10 is incident upon and

reflected by the reflector 12 to be incident, subsequently, upon the cholesteric polarizer 10.

The cholesteric polarizer 10 is arranged to transmit left hand (LH) circularly polarized light, and to reflect RH circularly polarized light. The RH component reflected by the cholesteric polarizer 10 is reflected by the reflector 12 and is thus converted to LH circularly polarized light which when incident upon the cholesteric polarizer 10 is transmitted thereby. Substantially all of the light emitted by the light source is therefore transmitted by the cholesteric polarizer 10 in the form of LH circularly polarized light.

A quarter wave film 14 is located adjacent the cholesteric polarizer 10 and is arranged to convert the LH circularly polarized light to a component of linearly polarized light which, in Figures 1a and 1b, is denoted by a dot.

The linearly polarized light is incident upon a spatial light modulator (SLM) 16 in the form of a liquid crystal layer 18 which is provided between a pair of glass substrates 20. Red, green and blue colour filters 22 are located between one of the glass substrates 20 and the liquid crystal layer 18. The molecules of the liquid crystal material forming the layer 18 are aligned using conventional techniques, and electrodes are provided to permit control of the orientation of the liquid crystal molecules.

In use, with the liquid crystal molecules oriented so that the polarization of light transmitted by the liquid crystal layer 18 is rotated by 90° as illustrated in Figure 1a, the light transmitted by the liquid crystal layer 18

is linearly polarized in the direction denoted by a double headed arrow in Figure 1a. This light is incident upon a quarter wave film 24 which is oriented to convert the linearly polarized light to LH circularly polarized light.

An output RH cholesteric polarizer 26 is located adjacent the quarter wave film 24. As the RH cholesteric polarizer 26 transmits LH polarized light, the light transmitted by the liquid crystal layer 18 and quarter wave film 24 is transmitted through the output cholesteric polarizer 26 and out of the device. Thus the device appears bright.

If the liquid crystal layer 18 is controlled so as to have no effect on the polarization of light transmitted thereby as illustrated in Figure 1b, then the light incident upon the quarter wave film 24 is linearly polarized in the direction denoted by a dot. The quarter wave film 24 converts this light to RH circularly polarized light which is reflected by the output cholesteric polarizer 26 and not transmitted thereby. Thus the device appears dark.

The light reflected by the output cholesteric polarizer 26 returns through the quarter wave film 24 where it is converted to linearly polarized light denoted by a dot, through the SLM 16 to the quarter wave plate 14 which converts the light to LH circularly polarized light. The LH circularly polarized light is transmitted by the input cholesteric polarizer 10 and is reflected by the reflector 12, such reflection converting the light to RH circularly polarized light. As described before, such light is reflected by the cholesteric polarizer 10, reflected by the reflector 12 where it is converted, once more, to LH circularly polarized light which is transmitted through the cholesteric polarizer 10.

The liquid crystal layer 18 will, in practice, define a matrix of pixels, each pixel being individually controllable. By arranging the colour filters 22 such that each filter 22 is adjacent a respective pixel or group of pixels, the device can be arranged to display colour images.

As the polarizers used in the arrangement of Figures 1a and 1b reflect rather than absorb the non-transmitted polarization component, the brightness of an image displayed on the device is enhanced, or a light source of reduced output may be used.

The cholesteric polarizers 10, 26 may be laminated to the SLM 16, the quarter wave films 14, 24 being located therebetween. The reflection of ambient light by the output cholesteric polarizer 26 may be disadvantageous. Such frontal reflections may be avoided by using the display in a darkened environment. Alternatively, holographic reflectors, for example as described in Chen et al (SID95 digest p.176-9) may be used to reduce the reflection of ambient light towards an observer.

Where the device is used in a projection system, frontal reflections are less of a disadvantage.

Alternatively, the cholesteric polarizers 10, 26 and quarter wave films 14, 24 may be located within the SLM 16 between the glass substrates 20 thereof. Such an arrangement reduces the risk of damage to the cholesteric polarizers 10, 26, but does not overcome the disadvantageous effects of reflection, for which purpose conventional anti-reflective coatings may be provided on the output glass substrate 20.

As a further alternative, the polarizers 10, 26 may be located between the substrates 20, the quarter wave films 14, 24, and, if required, additional linear polarizers being laminated subsequently to the substrates 20. Such an arrangement is possible because cholesteric liquid crystal polymer materials are able to withstand the high temperatures necessary for the production of alignment layers and deposition of electrodes, for example 200°C for up to 1 hour, without significant degradation of their optical properties, conventional polarizing materials not being capable of withstanding such conditions. Subsequently, the quarter wave films 14, 24 are applied.

In order to avoid a pixel which is intended to appear dark actually appearing bright, it is desirable for the light reflected by the output cholesteric polarizer 26 to be reflected back through the same pixel of the liquid crystal layer 18 as it was previously transmitted by. This places constraints upon the separation of the output cholesteric polarizer 26 from the liquid crystal layer 18, and upon the range of angles from which the displayed image can be viewed. Where the output polarizer 26 is 20 μm thick and is laminated to the outside of a 1 mm thick glass substrate, then for a pixel size of 100 μm and fill factor of 50%, the angle of incidence of light on the liquid crystal layer 18 should not exceed 3°. Thus a highly collimated light source should be used. Where the output cholesteric polarizer 26 is located within the SLM 16, the maximum permitted angle of incidence increases to approximately 70°. A further advantage of disposing the cholesteric polariser 26 between the substrates 20 is the substantial reduction in cross talk between adjacent pixels. This is particularly desirable in autostereoscopic and stereoscopic displays so as to avoid cross talk between left and right eye images. Thus, for many applications of the

embodiments of the invention where reduced cross talk, wide viewing angle and reduced constraint on light source collimation are desirable, it is preferred to dispose the cholesteric polariser between the substrates. Embodiments of this type are described hereinafter.

Figure 2 illustrates an arrangement which is similar to that of Figures 1a and 1b but in which the absorbing colour filters 22 are replaced by reflective cholesteric colour filters 28. Each colour filter 28 is arranged to reflect light of a particular colour. Thus the upper sub-pixel of the device illustrated in Figure 2 will be for use in transmitting red light, the green component of light from the source having been reflected by the first layer of the filter 28, the second layer having reflected the blue component. Similarly, the second and third sub-pixels of the device are for use in transmitting green and blue light respectively.

The use of reflective colour filters instead of absorbing colour filters further enhances the brightness of the display, substantially all of the light incident upon a non-transmitting pixel or sub-pixel being returned to the reflector 12 and used elsewhere. For instance, considering the upper sub-pixel of the device shown in Figure 2, LH circularly polarised broad band light from the light source is supplied by the polariser reflector 10 and is incident on the green LH cholesteric colour filter element 28a. The element 28a reflects light in the green part of the spectrum while passing the remainder of the light to the blue element 28b. The element 28b reflects the blue light while passing the remaining red light to the quarter wave film 14. Thus, the filters 28 reflect all of the light not required to display a red pixel back towards the polariser reflector 10 for subsequent recycling as described hereinbefore.

When the liquid crystal pixel corresponding to the elements 28a and 28b is in the transmissive mode, the red light is transmitted through the quarter wave film 24 and the cholesteric polariser 26. When the liquid crystal pixel is in the non-transmissive state, the light emitted by the pixel is converted to RH circularly polarised light and is reflected by the polariser 26. The reflected light passes back through the liquid crystal layer 18, the quarter wave films 14 and 24, and the elements 28a and 28b for recycling as described hereinbefore. Accordingly, cholesteric colour filters of the type shown in Figure 2 may be used with the embodiments described hereinafter so as to improve the efficiency of use of light.

The embodiment of the invention illustrated in Figures 3a and 3b is similar to the arrangement described with reference to Figures 1a and 1b, the output quarter wave film and polarizer having been replaced by a patterned quarter wave film 30 and a patterned output cholesteric polarizer 32. The patterned quarter wave film 30 includes first regions 30a which are arranged to convert linearly polarized light denoted by a double headed arrow to LH circularly polarized light and that denoted by a dot to RH circularly polarized light, and second regions 30b arranged to convert linearly polarized light denoted by a double headed arrow to RH circularly polarized light and that denoted by a dot to LH circularly polarized light. The patterned output cholesteric polarizer 32 includes first regions 32a adjacent the first regions 30a of the quarter wave film 30 and arranged to transmit LH circularly polarized light, reflecting RH circularly polarized light, and second regions 32b adjacent the second regions 30b of the quarter wave film 30 and arranged to transmit RH circularly polarized light, reflecting LH circularly polarized

light. The quarter wave plate 24 and polariser 26 could be replaced by an absorbing linear polariser.

In use, an observer wears spectacles having polarized lenses arranged such that one of the observers eye's sees only LH circularly polarized light, his other eye seeing only RH circularly polarized light. By controlling the liquid crystal layer 18 such that the pixels thereof adjacent the first regions 30a display the image intended for one of the observers eyes, the pixels adjacent the second regions 30b displaying the image intended for the observer's other eye, a 3D stereoscopic image can be perceived by the observer.

Figure 4A illustrates an arrangement which is similar to that of Figures 3a and 3b. In this embodiment, the input cholesteric polarizer and quarter wave plate are replaced by a linear polarizer 34 which is arranged to transmit the polarization component denoted by a dot and to absorb that denoted by a double headed arrow.

Although the first and second regions of the patterned quarter wave film 30 and output cholesteric polarizer 32 are illustrated separately in Figure 4, it will be understood that the quarter wave film 30 and output polarizer 32 may be continuous and patterned as illustrated in Figures 3a and 3b.

The provision of the input polarizer 34 results in linearly polarized light being incident upon the liquid crystal layer 18, the device operating in the same way as that of Figures 3a and 3b with the exception that the input polarizer 34 absorbs rather than reflects one of the polarization components incident thereon.

The patterned quarter wave film 30 may be replaced by a single uniform quarter wave film with the result that the pixels adjacent the first regions of the output polarizer operate in a first mode, for example a normally white mode, whilst the other pixels operate in a second mode, for example a normally black mode. By using appropriate control techniques, such an arrangement permits a range of grey levels to be achieved. However, if the observer moves, the relative intensities of the views seen by the observer's eye change due to the two modes having different viewing angle performances.

The arrangement of Figure 4A is also suitable for use in an autostereoscopic system as shown in Figure 4B, the SLM having been reoriented so that the linear polarizer 34 faces the observer. In the autostereoscopic mode, a pair of opposed circularly polarized light sources are imaged through a suitable optical arrangement to define a pair of viewing zones. Each pixel of the liquid crystal layer 18 can only receive light from one of the light sources due to the presence of the input polarizers. By controlling the liquid crystal layer 18 appropriately, the images of a stereoscopic pair can be viewed from respective viewing zones. An observer whose eyes are located in respective viewing zones can perceive a 3D image.

The embodiment illustrated in Figure 5 is also similar to that of Figures 3a and 3b, the input cholesteric polarizer 10 and quarter wave film 14 having been replaced by a patterned cholesteric polarizer 35 including first regions 35a arranged to transmit LH circularly polarized light and second regions 35b arranged to transmit RH circularly polarized light and a patterned quarter wave film 36 including first and second regions 36a, 36b similar to those of the patterned quarter wave film 30 of the

embodiment of Figures 3a and 3b. The net effect of the input patterned cholesteric polarizer 35 and the patterned quarter wave film 36 is to apply one component of linearly polarized light, for example that denoted by a dot, to the liquid crystal layer 18. Thus operation of the device is as described hereinbefore.

In this mode of operation, a number of observers each wearing suitably polarized spectacles can perceive a three dimensional image.

As the first and second regions 35a, 35b of the input cholesteric polarizer 35 are arranged to transmit opposite handedness circular polarizations, this embodiment is particularly suitable for use in an autostereoscopic display device using a pair of polarized light sources and suitable optical elements to define appropriately positioned first and second viewing zones from which the images displayed by the pixels adjacent the first and second regions 34a, 34b can be observed, respectively, without the aid of polarizing spectacles, as described with reference to Figure 4B.

The embodiment illustrated in Figure 6 is similar to that of Figure 4A, the patterned quarter wave film 30 of the Figure 4A embodiment being replaced by a patterned polarization rotator forming a matrix of 90° polarization rotators 38 and compensation regions 40 which have no effect on the polarization of light incident thereon, and a quarter wave plate or film 42.

In use, the linearly polarized light transmitted by the pixels adjacent the compensation regions 40 is converted to circularly polarized light by the quarter wave plate 42. Thus depending upon the state of the liquid

crystal layer 18, either LH or RH circularly polarized light is incident upon the patterned output cholesteric polarizer region 32a which transmits RH light and reflects the LH component. Linearly polarized light from the liquid crystal layer 18 adjacent the 90° polarization rotators 38 is converted to the orthogonal linear component, and that component is incident upon the region 32b of the output cholesteric polarizer 32. If the liquid crystal layer 18 is controlled so that all pixels are in the same operating mode, then the provision of the 90° polarization rotators 38 results in the application of light of opposite handedness to the first and second regions 32a, 32b of the output cholesteric polarizer 32.

Figure 7 shows an embodiment similar to that of Figure 6 but in which the input linear polarizer 34 is replaced by a patterned cholesteric polarizer 35, quarter wave plate or film 44 and patterned polarization rotator 46 similar to that described with reference to Figure 6. The net effect of the patterned polarizer 35, quarter wave plate 44 and patterned rotator 46 is to apply one component of linearly polarized light to the liquid crystal layer 18. As described hereinbefore, as opposite handedness circular polarizations of light are applied to the different regions of the device, this device is also suitable for use in an autostereoscopic display arrangement.

As mentioned hereinbefore, the use of output cholesteric polarizers causes a significant proportion of ambient light to be reflected back to an observer. In the arrangement illustrated in Figure 8 this disadvantage is overcome by using absorbing polarizers 48 on the output side of the SLM in conjunction with polarization rotators 38 and compensation regions or plates 40, in other respects this embodiment being identical to

that of Figure 5. Alternatively, as shown in Figure 9, absorbing polarizers 50 may be used in conjunction with output cholesteric polarizers and a quarter wave plate 52 to absorb ambient light in order to avoid or reduce reflections. As illustrated in Figure 9, the absorbing polarizers 50 are patterned so as to permit light from the liquid crystal layer 18 to be transmitted. Alternatively, the quarter wave plate 52 could be patterned.

The absorbing polarisers 48 and 50 shown in Figures 8 and 9 are arranged such that their optic axes are parallel to the polarisation directions of the light leaving the associates pixels when these pixels are in the transmissive mode. Accordingly, the presence of the polarisers 48 and 50 causes little or no attenuation of light so that the brightness of the display is not substantially affected. However, ambient light incident on the output side of the displays is generally unpolarised. The polarisers 48 and 50 effectively divide the light into orthogonal components and the component which is polarised perpendicularly to the optic axis is absorbed. The other light component is transmitted into the display and may be reflected from the layers therein. Accordingly, the presence of the absorbing polarisers 48 and 50 attenuates reflection of ambient light by at least 50%. Display contrast is therefore substantially improved.

Figure 10 illustrates an embodiment using a phase change guest host liquid crystal layer 54 which is arranged such that, where no electric field is applied thereto, substantially all light incident thereon is absorbed and the material appears dark, light being transmitted when an electric field is applied thereto. A patterned output cholesteric filter including LH regions 56a which transmit RH circularly polarized light and RH regions 56b which transmit LH circularly polarized light is applied to the

liquid crystal layer 54. Thus each pixel transmits only light of one handedness, the other handedness being reflected back through the liquid crystal layer 54 to be absorbed or re-used elsewhere in the system.

The arrangement illustrated in Figure 11 is similar to that of Figure 10, the reflected components being viewed by an observer whilst the transmitted components are absorbed by an absorbent layer 58 or appropriately patterned polarizer or re-used elsewhere in the system.

In each of the embodiments described hereinbefore, the cholesteric polarizers may be replaced by reflective polarizers of another type, for example polarization sensitive holographic elements, and where the reflective polarizers are linear rather than circular polarizers appropriate changes to the retarders and polarization rotators should be made to the embodiments described hereinbefore.

Where cholesteric elements are used, the materials used are tuned to the wavelengths of light to be transmitted/reflected thereby. Additionally, the cholesteric polarizers may be used to generate colour for each pixel instead of using absorbing colour filters.

Any suitable type of liquid crystal material may be used, for example TN materials, supertwisted materials and materials which display variable birefringence e.g. Pi cells.

One possible technique for fabricating the patterned cholesteric polarizers is to deposit a uniform layer of cholesteric material on a substrate and then lithographically pattern the layer. By polymerizing regions of the material at different temperatures, a range of different

colour narrow wavelength band polarizers may be produced in at least one film.

Where the patterned cholesteric polarizers require regions of opposite handedness, the polarizer may be fabricated by depositing a layer of one handedness cholesteric material on a substrate. Regions of the layer are fixed by irradiation with ultra-violet light. The layer is then heated above the cholesteric/isotropic transition temperature and fully fixed by irradiating with UV light. A layer of the opposite handedness is then deposited and patterned by repeating the process.

In the embodiments where polarized spectacles are used, it is preferable to use circularly polarized 'lenses' in the spectacles in order to avoid cross-talk which may occur where linearly polarized 'lenses' are used and the observer tilts his/her head. Where circularly polarized 'lenses' 60 are used, it is convenient to fabricate the lenses 60 from suitable cholesteric materials as illustrated in Figure 12. Where the spectacles are used with an optical device arranged to transmit linearly polarized light, suitably oriented quarter wave plates/films (not shown) may be laminated to the cholesteric polarizers. Further, quarter wave plates 62 and absorbing polarizers 64 may be provided at the viewer side of the spectacles to absorb any of the 'wrong' component transmitted by the cholesteric polarizers 60.

As described briefly hereinbefore, it is advantageous to use an SLM the pixels of which all operate in the same mode in order to reduce the contrast performance differences between the pixels which occur when some pixels are normally white and others normally black when viewed from off-axis viewing positions. Where pixels having matched contrast

performances for on-axis viewing are viewed from different vertical positions, the differences between the brightness and contrast of the left and right eye views change as the observer moves, and may cause visual distress and false depth cues due to the Pulfrich effect. Hence the observer freedom of movement is limited.

It will be understood that a number of the embodiments described hereinbefore can be used in either an autostereoscopic or a stereoscopic mode. Switching between modes can be achieved, for example, by adjusting the mode of operation of the light source (for example as in the embodiment of Figures 4A and 4B), or by rotation of the SLM device.

CLAIMS

1. A liquid crystal device for use in a directional display, the liquid crystal device comprising a liquid crystal layer and a patterned reflective polarizer including at least one first region arranged to transmit a first polarization component and reflect a second polarization component and at least one second region arranged to transmit the second polarization component and reflect the first polarization component.

2. A device as claimed in Claim 1, wherein the patterned reflective polariser and the liquid crystal layer are disposed between first and second substrates.

3. A device as claimed in Claim 1 or 2, wherein the patterned reflective polarizer comprises a patterned cholesteric polarizer.

4. A device as claimed in Claim 3, further comprising a retarder.

5. A device as claimed in Claim 4, wherein the retarder is a patterned retarder.

6. A device as claimed in Claim 3, further comprising a polarization rotator.

7. A device as claimed in Claim 6, wherein the polarization rotator is a patterned polarization rotator.

8. A device as claimed in any one of the preceding claims, wherein the liquid crystal layer includes a plurality of pixels, a first group

of the pixels displaying a first image, and a second group of the pixels displaying a second image, in use.

9. A device as claimed in Claim 8, wherein the pixels of the first and second groups are all arranged to operate in the same mode.

10. A device as claimed in any one of the preceding claims, wherein the patterned reflective polarizer forms an output polarizer for the liquid crystal device.

11. A device as claimed in any one of Claims 1 to 9, wherein the patterned reflective polarizer forms an input polarizer for the liquid crystal device.

12. A device as claimed in Claim 11, further comprising an output patterned reflective polarizer.

13. A device as claimed in any one of the preceding claims, further comprising a directional polarized illumination system including a pair of oppositely polarized light sources and an optical system arranged to image the light sources at a pair of viewing zones.

14. A device as claimed in Claim 1, further comprising an absorbent layer arranged to absorb light transmitted by the patterned reflective polarizer.

15. A display arrangement comprising a device as claimed in any one of the preceding claims and polarized viewing spectacles having polarized eyepieces of opposite handedness of circular polarization.

16. A display arrangement as claimed in Claim 15, wherein the eyepieces include cholesteric polarizers.

17. Polarized viewing spectacles having a pair of eyepieces of cholesteric material, the eyepieces being arranged to transmit oppositely handed circular polarization components.

18. A liquid crystal device substantially as hereinbefore described with reference to and as illustrated in Figures 3a to 12 of the accompanying drawings.

The Patent Office

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Application No:	GB 9612347.6	**Examiner:**	Mr.G.M Pitchman
Claims searched:	1 to 16	**Date of search:**	29 August 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G2F (FSX) H4F (FDD)

Int Cl (Ed.6): G02F 1/1335 H04N 13/00

Other: ONLINE: EDOC WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2296151 A	(SHARP)-see claims 1, 12 and 18	1-16
X	EP 0477882 A2	(HONEYWELL)-see column 2 line 7 to column 4 line 3	1-16
X	US 5264964	(FARIS)-see column 2 line 47 to column 4 line 7	1-16

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

The Patent Office

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Application No:	GB 9612347.6	**Examiner:**	Mr.G.M Pitchman
Claims searched:	17	**Date of search:**	25 February 1997

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G2J (JX15)

Int Cl (Ed.6): G02C 7/12 G02B 27/22 H04N 13/00

Other: ONLINE: EDOC WPI JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	EP 0349692 A2 (KAISER)-see column 12 lines 9 to 45	17

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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